April 1945 E-64

United States Department of Agriculture
Agricultural Research Administration
Bureau of Entomology and Plant Quarantine

SUMMARY OF TESTS WITH DDT IN 1944 FOR CONTROL OF FOREST INSECTS

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During the past year DDT has been tested on an experimental scale for the control of a number of forest insects. These experiments indicate that no development in the last 25 years has offered so much promise for the control of many forest insects, particularly defoliators. Judging from these experiments, DDT is far more effective in low concentrations than any other commercial insecticide. Because of the small amount required per acre, it is especially well suited to application from airplanes, and indications are that it may make possible the protection of extensive areas of valuable timberland. The remarkable residual qualities of the DDT deposit make it particularly well adapted for the control of certain species. Its toxic effect, however, on beneficial insects, fish, and wildlife in the forest is a problem which will require thorough investigation, and such investigations are underway in cooperation with the Fish and Wildlife Service, U. S. Department of the Interior, and other agencies.

The material presented here is summarized from reports on experiments conducted at several field laboratories of the Division of Forest Insect Investigations, as indicated. The more detailed results of these investigations are being published under authorship of the workers who conducted the studies.

DDT has been tested against defoliators, bark beetles, wood borers, termites, and a number of sucking insects. It has been applied in the form of suspensions, solutions, and emulsions, by means of airplanes, high-powered sprayers, knapsack sprayers, and hand atomizers. Early experiments with forest insects indicated that DDT mixed with ground pyrophyllite and applied as a dust was effective in only a few specific cases. With DDT suspensions there was considerable survival among the insects tested. Consequently, most of the experimental work has been conducted with solutions and emulsions.

A large number of solvents and emulsifying agents have been used in developing the various spray formulas that have been tested and further work along this line is underway.

Aerial Application of DDT

Experiments in the aerial application of DDT were conducted cooperatively by P. B. Dowden of the New Haven, Conn., laboratory of the Division of Forest Insect Investigations, and D. Whittam of the Division of Gypsy and Brown-Tail Moths Control, Greenfield, Mass. These applications were for the control of the gypsy moth (Porthetria dispar (L.)), the green-striped maple worm (Anisota rubicunda (F.)), the red-headed pine sawfly (Neodiprion lecontei (Fitch)), and the spruce budworm (Archips fumiferana (Clem.)). Complete control of the gypsy moth was obtained in a 20-acre oak woodland with 5 pounds of DDT in 5 gallons of solvent per acre, applied before the eggs had hatched and before the foliage appeared. Later tests with the same dosage killed all the second- and third-stage larvae of the gypsy moth in a 5-acre woodland plot. The spray formula used in these tests consisted of 1 part by weight of DDT, 1 part of cyclohexanone or 1.5 parts of xylene, and 7 parts of a light oil. A similar formula was used in nearly all subsequent tests, except that from 1.5 to 1.8 parts of xylene was substituted for 1 part of cyclohexanone as a DDT solvent. The spray settled through the forest canopy to the understory as a fine mist, leaving, upon evaporation of the liquid, a uniform crystalline deposit of DDT on all parts of the trees.

Complete control of the green-striped maple worm was obtained with the same dosage in a Vermont maple-sugar orchard.

Complete control of the red-headed pine sawfly in a red pine plantation in northern New York was obtained by applying 2½ pounds of DDT per acre. On the fringes of this sprayed area, where the spray drifted, complete control was obtained with a dosage believed to be not more than 1 pound of DDT in 1 gallon of liquid per acre.

The results of aerial tests in Canada against the spruce budworm cannot be evaluated until 1945. However, tests with high-powered ground equipment, conducted at the Fort Collins, Colo., laboratory by L. W. Orr and N. D. Wygant, demonstrated that the spruce budworm can be controlled with dosages as low as 2.5 pounds of DDT per acre, applied as an emulsion in linseed oil or as a finely divided alcohol-water suspension. Some of the sprays were applied prior to larval activity in the spring; others were used when the larvae were one-half to full grown. There were indications that the early applications, which killed the young larvae as they began feeding, were partially effective in killing the moths several weeks later; therefore, one treatment may result in control of two generations of some species of insects.

Because of the success obtained with these lower dosages during the spring and summer of 1944, an extensive series of aerial tests were made during September to determine the results from further reduction

of dosage. The observations indicated that the gallonage of spray per acre must be varied according to the volume or area of foliage to be treated. Tentatively, it appears that, where there is relatively little foliage, as in plantations, good control may be expected from 1 pound of DDT in 1 gallon of liquid per acre, whereas under forest conditions possibly twice that amount may be required. In the control of many forest insects, however, a complete kill may not be necessary to obtain the desired objective. In many cases preventing defoliation to an extent that will enable the trees to survive will be sufficient. Coverage, therefore, need not be complete and perfect lapping of the swaths is not necessary. It may be possible to use considerably lower dosages to accomplish this objective. Further development of distributing equipment and the use of larger planes may eventually make it possible to treat several hundred acres of woodland with one load of insecticide.

Effect of DDT on Water and Wildlife

A 40-acre wooded watershed surrounding a 3-acre reservoir in Pittston, Pa., was treated by airplane with 5 pounds of DDT in 5 gal-lons of liquid per acre, for the purpose of determining the amount of DDT present in the reservoir after rain. The area was treated on August 14, and by August 17 three-fourths of an inch of rain had fallen. Water samples were taken from the reservoir and from the tap of a factory nearby. Chemical analysis of these samples made by the Division of Insecticide Investigations showed that each sample contained less than 1 part of DDT per 100 million parts of water. Such small amounts, in the opinion of the Food and Drug Administration, Federal Security Agency, could result in no health hazard from consumption of the water.

A study of the watershed area and the reservoir was made by P. B. Dowden of the Division of Forest Insect Investigations, H. K. Townes of the Division of Insect Identification, and N. Hotchkiss of the Fish and Wildlife Service, to determine the effect of DDT on the fauna of the forest and the reservoir. Briefly it may be stated that the application of DDT severely reduced the abundance of most insects present in the forest, but for the majority of species a sufficient number were left to repopulate the area. Sufficient spray drifted on to the reservoir to cover the surface of the water with a light film of oil. Within a few hours this oil film was blown by the wind to one end of the reservoir. There was a high mortality of adults of a number of species of aquatic insects which were on or near the surface of the pond. Some mortality of immature stages of insects at the surface of the water was noted. The insects living on the bottom of the reservoir seemed to be unaffected by this treatment.

There was no indication of mortality among the bird life of the forest, but owing to the mobility of the bird population at the time of the spraying it cannot be concluded that there was no effect. The only effect noted on other vertebrates was on the day following treat- ment, when a number of leopard frogs and bullfrogs and a few sunfishes and minnows were dead or seriously affected. Unfortunately time did not permit a careful study of this area except for a few days subsequent to treatment. However, general observations on the 20-acre gypsy moth plot sprayed early in the spring indicated that the fauna were back to normal in 10 or 12 weeks. It was generally concluded that a thorough ecological investigation of the effect of DDT on the fauna of forests, lakes, and streams should be undertaken before recommendations are made for the treatment of extensive forested areas.

Wood Borers and Termites

Preliminary work with DDT by R. A. St. George, at Beltsville, Md., H. R. Johnston, at Saucier, Miss., and R. C. Hall, at Berkeley, Calif., indicates that it may be an effective insecticide for use on valuable logs to prevent the attack of bark beetles, ambrosia beetles, and wood borers. Protection lasting 2 months was obtained with 2- to 10-percent solutions in diesel oil or kerosene. Wood borers such as Monochamus and Acanthocinus were more easily killed or repelled than bark beetles and particularly ambrosia beetles. The latter require concentrations of at least 5 percent. Tests in Mississippi were less effective than those at Beltsville, the great difference in rainfall probably being an im-portant factor.

Preliminary work by C. H. Hoffmann at Asheville, N. C., and R. A. St. George at Beltsville, indicates that DDT is very toxic to termites, both as a soil poison and in treated wood. In the latter case, however, it is of limited value because it has no fungicidal properties. Tests with fiberboard are under way in the Tropics. Fabrics treated with 5- percent solutions of DDT have been resistant to termite attacks, and tests with lower concentrations are now being conducted. Fabrics treated with DDT were severely damaged by mildew and decay.

Bark Beetles

DDT in an oil emulsion was tested by N. D. Wygant in the laboratory for the prevention of attack by the Engelmann spruce beetle (Dendroctonus engelmanni Hopk.) a bark beetle attacking living spruce trees in Colorado. Preliminary results indicate that the beetles were prevented from attacking green logs and finally all were killed.

Extensive experiments conducted by R. R. Whitten at the Morristown, N. J., laboratory with sprays containing DDT have given very promising results in controlling the smaller European elm bark beetle (Scolytus multistriatus (Marsham)) the principal vector of the Dutch elm disease pathogen. Various solutions and emulsions containing from 2 to 5 percent of DDT were effective in preventing crotch feeding in living elm trees by adult beetles for more than 110 days. Lower concentrations of DDT were effective for shorter periods. Similar sprays containing as little as 0.25 percent of DDT prevented beetles from entering the bark of sprayed logs for over 69 days, and when the concentration of DDT was increased to 2 percent the period of protection was extended to more than 160 days. An emulsion containing 0.5 percent of DDT, when applied to elm wood infested with larval broods, permitted some emergence of adults, but affected these emerging beetles to the extent that none were able to attack suitable material caged with them. Solutions of as little as 0.25 percent of DDT, when applied to similar infested material, prevented all emergence.

Leafhoppers and Lygus

A number of preliminary cage and field tests were conducted at the Columbus, Ohio, forest-insect laboratory by W. L. Baker and T. J. Parr, with sucking insects, such as treehoppers and leafhoppers, suspected of transmitting the virus that causes the elm phloem necrosis disease. R. F. Anderson, at the Milwaukee, Wis., Laboratory, conducted similar tests with the Saratoga spittle bug (Aphrophora saratogensis (Fitch)), which causes a twig blight on pines in plantations in the Lake States. Oil emulsions containing from 0.1 to 1 percent of DDT were tested. Nearly all species readily succumbed to these dosages, within 24 hours, indicating that these sprays may have much promise in preventing such sucking insects from feeding. In the case of the spittle bug, sprayed trees showed no sign of tip kill at the end of the season. The material appeared to have a distinct repellent effect, but when the insects were caged on sprayed branches complete mortality usually resulted in 24 hours.

DDT has been found very effective against several insects affecting the rubber-producing plant guayule. Lygus hesperus Knight, a plant bug which has been notoriously hard to control on cotton and other plants, succumbed readily to 2- to 5-percent DDT dusts and to emulsions containing from 0.15 to 0.3 percent of DDT. Mites were readily controlled with emulsions of DDT.

Miscellaneous Forest Insects

Less extensive tests have been made on a considerable variety of insects. For example, the eastern tent caterpillar (Malacosoma americana (F.)) is effectively controlled by a very small amount of DDT spray (such as 0.1 percent) applied as an emulsion to the egg bands or later to the foliage or tents. The fall cankerworm (Alsophila pometaria (Harr.)), the fall webworm (Hyphantria cunea Drury), the mimosa webworm (Homadaula albizziae Clarke)), the bagworm (Thyridopteryx ephemeraeformis (Haw.)), the catalpa sphinx (Ceratomia catalpae (Bdv.)), and the boxwood leaf miner (Monarthropalpus buxi Laboulb.) were all readily controlled in small-scale tests with concentrations of 0.1 to 1 percent. The abundance of black flies, mosquitoes, and deer flies was noticeably reduced in a number of sprayed plots, and high mortality occurred among parasites. Adults of the locust borer (Cyllene robiniae (Forst.)) were killed when DDT was applied as an emulsion either to the goldenrod on which the beetles feed or to the stems of locust trees prior to oviposition. Preliminary tests indicate that a 1-percent DDT emulsion may be used to control the white pine weevil (Pissodes strobi (Peck)), by killing the adult beetles coming to the sprayed trees. J. E. Patterson found it effective against the reproduction weevil (Cylindrocopturus eatoni Buchanan)) in California. For the control of carpenter ants 17 log cabins in the Superior National Forest in Minnesota were sprayed by H. C. Secrest with 1- and 5-percent solutions of DDT in kerosene. Satisfactory control was obtained with a 5-percent solution.

In general, DDT has been used most effectively as a contact spray. It is especially toxic to young larvae. There is considerable indication, from work of S. F. Potts at New Haven, Conn., that it is also highly toxic to mature larvae when used as a stomach poison in relatively low dosages. As little as half a pound per acre gave good control of last instars of the gypsy moth on small hand-treated plots of low-growing trees.

Effects of Solvents Used in Formulations

Laboratory tests during the present winter, conducted at Beltsville by R. A. St. George, C. H. Hoffmann, and others, and prompted by results obtained from field applications made by R. R. Whitten during the summer, indicate that the nature of the solvents used with DDT has an extremely important bearing on toxicity. Some solvents, such as kerosene, evaporate quickly (a matter of minutes) leaving slender, needlelike crystals that are very durable, the toxic effects lasting from 3 to 6 months under outdoor weathering. These tiny crystals may penetrate between the footpads of the insects and possibly enter the pores in the sclerites of the body. Velsicol AR-50 (a mixture of mono- and di-methylnaphthalene) produces similar crystals, but these require a day or more to form. Heavy solvents, such as diesel oil, remain

tacky for days and leave a deposit that is not so persistent as that resulting from kerosene. On the other hand, these tacky or viscous films kill several times more quickly.

Relation of Insecticides to Silviculture

Forest entomologists have never been very enthusiastic about the use of insecticides, because of cost and impracticability of applica-tion. On the other hand, forest entomologists have repeatedly proposed silvicultural recommendations as a means of preventing outbreaks of forest insects. In a way such suggestions have been a bit before their time, for actually there have been few satisfactory tests of these suggestions. Many of them appear to have merit, and no doubt when it becomes possible to test them on a large scale they will prove satis-factory. Until economic conditions permit more intensive forest manage-ment, the advent of DDT bids fair to bridge the gap with a fairly practi-cal means of control. Nothing that can be said about the use of DDT at present should be construed as obviating the need of encouraging every practice that will make forest areas more resistant to insect outbreaks.

However, before DDT can be generally recommended for public use, careful investigations must be conducted to determine the most effec-tive and practical formulas for various uses, and its possible dele-terious effect on man and domestic animals, beneficial insects, fish, and wildlife. The expanding experimental programs should bring these answers shortly.